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Docket No. AM1562D1

REMARKS

I. CLAIMED INVENTION

The present invention addresses the need for forming openings in silicon that can be filled with another material without leaving any voids, either along the sidewalls or at the bottom of the openings. In addition, the openings must be able to be made deeper than devices formed in the silicon substrate. Thus the openings must have straight walls that are perpendicular to the substrate, the etchant must not deposit solids along the sidewalls that can eventually close the openings, and the bottom of the openings must be well rounded.

Further, the plasma etchant must be selective with respect to a patterned or masked resist layer; that is, it must attack the silicon at a faster rate than the resist so that the etch mask is not consumed before the desired opening depth is attained.

Still further, the etchant must have a fast etch rate to accommodate present-day one-at-a-time substrate processing equipment.

These are very stringent requirements, but are necessary as semiconductor devices become smaller in size and more closely

packed.

Etchant mixtures known heretofore are at least somewhat isotropic rather than anisotropic; they deposit polymeric materials along the sidewalls that clog the openings; they form shaped or bowed sidewalls; they may have slow etch rates; they may require high power that damages the substrate or devices formed therein; and they may cause microloading, e.g., produce different etch rates at different positions along the substrate.

Applicant has found a particular gaseous etchant mixture for a substrate mounted in a plasma etch chamber onto a powered substrate support that satisfies all of the requirements enumerated above.

The invention, as illustrated in Fig. 3, shows high aspect ratio openings in silicon with straight walls, rounded bottoms, openings that are perpendicular to the substrate surface, and that do not have any deposited material on the opening sidewalls.

In comparison, as shown in Fig. 4 for Control 1 that employed an etch mixture of sulfur hexafluoride and oxygen, when hydrogen bromide is omitted from the etch mixture, an isotropic etch forms at the top of the trench.

As shown in Fig. 5, Control 1 produces a highly isotropic

initial etch.

As shown in Fig. 6, illustrating Control 3, when sulfur hexafluoride is omitted, the etch rate is too low for economic processing.

As shown in Fig. 7, illustrating Control 4 that employed a mixture of oxygen and nitrogen trifluoride as the etch gas, the opening was highly isotropic and the etch rate is low.

Fig. 8 illustrates openings formed according to Control 5, which used both sulfur fluoride and a fluorohydrocarbon plus oxygen, but omitted hydrogen bromide. These openings display some isotropy under the mask, some roughness of the sidewalls and a very low etch rate.

Thus the Control Examples show that etch mixtures having some, or different, etch gases than those claimed, do not attain the desired results.

II. CLAIM OBJECTIONS

Former claims 5 and 6, now cancelled, were objected to as being dependent upon a dependent claim. In view of their cancellation, this objection should be withdrawn.

Claim 1, now cancelled, was objected to as indefinite in the Markush expression. New claim 11 overcomes this rejection.

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III. CLAIM REJECTIONS

Claims 1-3 were rejected over Komura in view of Harshbarger et al. This rejection is respectfully traversed with respect to the present claims. Applicant submits the references, rather than render the present claims obvious, teach away from the presently claimed invention, the antithesis of obviousness.

Example 1 of Komura requires hydrogen bromide as the principal etch gas, with minor amounts of both SF_6 and SiF_4 and the addition of helium-oxygen. Comparative Example 3, which omits silicon hexafluoride altogether, did not etch silicon. Komura's conclusion is that both sulfur hexafluoride and silicon tetrafluoride are required for the etch. None of his examples used a mixture of the three ingredients required by the present claims.

The reactor of Komura does not include a gas inlet electrode, as required by the present claims. Instead, the reactor of Komura, as illustrated in Fig. 3, has a gas inlet 302 that is in addition to a first electrode 304.

Thus applicant submits Komura teaches away from the present claims, rather than renders the present claims obvious.

Harshbarger does not supply the inadequacies of Komura.

Harshbarger describes as etchants those including chlorine species, fluorocarbons or chlorofluorocarbons. The Examples use a combination of chlorine and the fluorocarbon C_2F_6. No oxygen is added at all. Further, the substrate is mounted on a grounded electrode. As seen in the Table in col. 9, as the chlorine content increases, the etched openings become more isotropic; but at low chlorine content, the etch rate and selectivity with respect to the resist is low. Thus Harshbarger does not suggest the presently claimed invention either, and, even if these references are considered together, they do not suggest or render the present claims obvious.

IV. CONCLUSION

In view of the above newly presented claims, and the above remarks, applicant submits the present claims are allowable. Accordingly, reconsideration and allowance of claims 11-14 are respectfully solicited.

Respectfully submitted,

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